AIA Honolulu

A Chapter of The American Institute of Architects

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13 April 2009

City Council Public Hearing
Budget Committee: Special Meeting

Re: Bill 16 (2009) Executive Operating Budget and Program, (Item TF) Transit Improvement Bond Fund

Transit Testimony of Sidney Char, AIA, on behalf of AIA Honolulu

My name is Sidney Char, AIA and I am here to represent the Honolulu Chapter of the American Institute of Architects (AIA). I was the President of the AIA in 2008 and am a member of the AIA Transit Task Force, whom has been responding to the City's proposal for Honolulu's Transit System.

As a matter of background, the AIA has always been interested in the planning and design issues in our community. Back in 2006, the mayor spoke to our membership and indicated that it was too early for the architects to participate in the design of the transit. Then in 2007, Mr. Toru Hamayasu of the City stated that it was too late for architects to participate in the overall system; indicating that he believed that architects were only to be involved in the design of the stations and its appearance.

In 2008, the AIA started opening up communication with the city to discuss our concerns with the proposed system. Our original concern was the aesthetics of the imposition of the large concrete structures across our island landscape and the impacts to the downtown urban core with the interruption of the *mauka* and *makai* views and the separation of the waterfront from our city center. At another public forum with our AIA memberships, the mayor listened to our design concerns and then he invited us to come up with a better solution and to present it to him. He stated that ultimately the transit would be built under a different mayor and the city council is ultimately responsible for approving the system.

The AIA then formed a Transit Task Force to start researching transit systems so we could speak as a more informed group. Our independent research revealed some very compelling information that we believe may offer Honolulu a superior system at a lower cost and built in less time. Given the economic challenges today, we believe it is very important to seriously compare the current proposed elevated system to an at-grade light rail system.

The AIA does support a rail transit system and believes that a viable at-grade system could be completed and maintained for less money, saving all of our taxpayers billions of dollars. We believe with the lower costs, the city would not need to appropriate this Transit Improvement Bond Fund for almost a billion dollars.

AIA Honolulu
119 Merchant Street, Suite 402
Honolulu, Hawaii 96813-4452
Phone: 808.545.4242
Fax: 808.545.4243
Website: www.aiahonolulu.org

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The AIA is submitting our AIA Task Force Report on light rail transit for the Honolulu High Capacity Transit Corridor Project for your review. Many of the advantages of the proposed at-grade light rail system are: the system's flexibility, increased accessibility, revitalization of the existing communities along the entire route, enhanced security, no need for large expensive transit stations, less maintenance of elevated station facilities with elevators and escalators, easier inter-modal connectivity, better compatibility with local environments and improved visual aesthetics.

Our report includes a comparative analysis between the City's proposed elevated rail and an at-grade light rail transit. We believe that the dramatic variance in the cost of elevated at two to three times the cost of the at-grade system ($5.3 Billion vs. $2.5 billion) is a huge factor that bears reconsideration. The other factor is the operation and maintenance of the elevated is 40% higher or projected at $25 million more per year. Based on the City's projected ridership at 95,050 riders, the cost is $663 per rider per year.

The projected construction time for the at–grade system is more than half the time at 4 years instead of 9 years. This means that the entire system will be operational and financially contributing to the debt service that much sooner. The shorter construction time will also be less disruptive to businesses and residences along the proposed route of the transit.

We have learned that in the last thirty (30) years, only one city elected to build an elevated rail system, and that is Miami, while thirty five (35) other cities have all elected to go with at-grade light rail transit. We believe that other cities chose the at-grade alternative because of the overriding advantages and cost differences. The elevated system in Miami looks very large and bulky and foreboding in appearance. It is not very compatible with the surrounding environment. The at-grade transit is more user and environmentally friendly and more appropriate for our island communities.

In summary, the AIA is here to ask the City Council to reconsider the serious environmental and financial impacts of the proposed elevated rail and select a flexible technology such as the overhead catenary wire and/or the intermittent power third rail and a more economical solution. The flexibility in technology allows subsequent sections or future lines to be added to the rail system either below grade, at-grade or elevated at less cost. We have all seen costs escalate over time and we believe the difference in cost may be even greater than projected for the elevated guideway. Even though millions of dollars of preliminary engineering has already been spent, we are still talking about billions of dollars that could be saved by selecting the at-grade light rail transit.

Thank you for this opportunity to present our Transit Task Force Report and to summarize our research on viable, money-saving alternatives for the Honolulu High Capacity Transit Corridor Project.

AIA Honolulu
119 Merchant Street, Suite 402
Honolulu, Hawaii 96813-4452
Phone: 808.545.4242
Fax: 808.545.4243
Website: www.aiahonolulu.org

AIA Honolulu

A Chapter of The American Institute of Architects

American Institute of Architects/Honolulu Chapter
TASK FORCE REPORT: SUGGESTED LIGHT RAIL TRANSIT (LRT) FOR THE HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT

EXECUTIVE SUMMARY

The Honolulu Chapter of the American Institute of Architects (AIA Honolulu) continues to strongly support the concept of a fixed rail transit system for Oahu. However, we also remain concerned over the appropriateness of the proposed elevated transit system particularly through the urban core of Honolulu. We therefore respectfully offer this report to assist the City administration, lawmakers, and stakeholders in strengthening community support, enhancing our neighborhoods and environment, investing taxpayer money wisely, and ensuring Federal funding for this historic project.

AIA Honolulu promotes the implementation of a flexible transit system capable of operating at, above, or below grade to accommodate the particular conditions within each community. Widely used transit technologies such as light rail transit (LRT) with overhead catenary wires allow transit planners this greater flexibility while still satisfying transit design criteria for passenger volume and frequency of service.

In light of the current economic recession, a predominantly at-grade light rail solution would offer Oahu residents a more cost effective transit system built in less time. Such a system would also be cheaper to operate and maintain, annually conserving taxpayer money. The resulting cost savings could be directed toward extending the system to UH Manoa, Waikiki, and perhaps even to Kahala Mall and Mililani/Wahiawa/Haleiwa.

At-grade systems would encourage diverse, mixed-use Transit Oriented Development (TOD) along the entire length of the transit route and help revitalize existing communities and buildings rather than concentrating new development only at station locations. Increased accessibility tends to stimulate ridership and promote inter-modal connectivity. Such systems more easily complement active streetscapes and vibrant public spaces, helping to enhance Honolulu's sense of place. Compared with elevated rail, the minimal visual and environmental impacts of at-grade systems further preserve our unique island scenery for our visitors and residents alike.

The chart on the following page summarizes the findings in the report:

AIA Honolulu
119 Merchant Street, Suite 402
Honolulu, Hawaii 96813-4452
Phone: 808.545.4242
Fax: 808.545.4243
Website: www.aiahonolulu.org

PROJECT CRITERIA	ELEVATED RAIL	AT-GRADE LRT
Overall Construction Cost (20 mile system)	$5.3 Billion+	$2.5 Billion
Construction Cost per Mile	$265 Million+	$125 Million
Construction Time	9 years	Approx. 4 years
Construction Energy Consumption per Mile	170,000 MBTUs	20,000 MBTUs
Operation & Maintenance Cost (OMC)	$63 Million per year	$39 Million per year
Visual Impact	Moderate/High	Low
Environmental Impact	High	Low
Potential for TOD	Limited to areas near station entrances	Several major advantages for TOD
At-grade Traffic Impact	Low	Acceptable, using signal synchronization
Passenger Capacity (Passengers per Hour per Direction)	6,000	over 9,000
Current systems in North America	1 city	35 cities

+ The lack of recent all-elevated rail projects makes it difficult to verify projected costs.

SUGGESTED LIGHT RAIL TRANSIT (LRT) FOR THE HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT

AIA Honolulu continues to strongly support the concept of a fixed rail transit system for Oahu. However, we also remain concerned over the appropriateness of the proposed elevated transit system particularly through the urban core of Honolulu. AIA Honolulu promotes the implementation of a flexible transit system capable of operating at, above, or below grade to accommodate the particular conditions within each community. To assist the City administration, lawmakers, and community in strengthening community support, enhancing our neighborhoods and environment, investing taxpayer money wisely, and ensuring Federal funding for this historic project, AIA Honolulu's Transit Task Force has prepared the following comparison study of two different types of fixed rail systems:

- The elevated "hot" third rail system currently proposed in the Draft Environmental Impact Statement (DEIS) dated November 2008, and
- At-grade light rail transit (LRT) systems using an overhead "catenary" power wire

The LRT system was chosen for consideration in this study because of its flexibility; LRT guideways can be put at grade, below grade or overhead as required by planning considerations. The two rail systems are compared in terms of:

- Construction Costs
- Operating and Maintenance Costs
- Visual and Environmental Impact
- Transit-Oriented Development, and
- At-grade Traffic Impact

I. CONSTRUCTION COST

Elevated rail

The latest cost estimate for the 20-mile, 20-station elevated rail system proposed for the City & County of Honolulu is $5.3 billion, or $265 million per mile[1]. This figure is for the initial phase from Kapolei to Ala Moana and does not included extensions to Waikiki or UH Manoa. Due to the scarcity of recently built elevated systems, it remains difficult to evaluate these projected construction costs. The only instance in which an all-elevated mass transit line was built in a major city in the United States occurred in Miami in the 1970's, which is too long ago to provide reliable cost data.

Given the large cost overruns of recent transit projects in Hawaii (H-3)[2] and elsewhere in the country (Boston's "Big Dig", Los Angeles subway), and the lack of construction data from elevated transit projects, we are concerned that current cost estimates and contingencies may not be adequate.

At-grade rail

Currently there are 35 at-grade rail systems operating in urban areas of North America[3] (Appendix 1). These systems all use an overhead power wire and steel rails at grade (ground) level in dedicated street lanes or other existing public right-of-ways. A number of these systems have been built within the last 5 years and can offer a more accurate idea of projected construction costs if a 20-mile at-grade system was built in Honolulu.

The at-grade LRT systems in Charlotte, Houston, Los Angeles, Minneapolis, Phoenix, Sacramento, San Francisco and San Jose were all completed between 2003 and 2008, with the Phoenix line having just opened in December 2008. Final per-mile costs for these systems ranged from $43 million (Houston) to $70 million (Phoenix)[4]. Using the final cost of the Phoenix system ($1.4 billion) and the current cost multiplier for construction costs in Hawaii (1.79 times Phoenix costs)[5] we conservatively estimate that the total cost of a 20-mile at-grade LRT system in Honolulu would be approximately $2.5 billion at today's prices.

The lower construction cost of at-grade rail is primarily due to the savings on materials (steel and concrete), energy and labor required to construct the elevated guideway and stations anywhere from 35 to 80 feet above ground level[6]. Secondly, there are savings on the machinery (stairs, escalators, elevators) and lighting needed at each elevated station as well as the mezzanine structures which span the street below the stations. In addition, there are substantial savings on below-grade foundation and utility realignment work needed for support of the structural columns in an elevated system.

Land Acquisition Costs: Elevated Rail

According to the latest reports from the City administration, a total of 189 properties are in the path of the proposed elevated line and will have to be acquired in part or in full[7]. The city has budgeted $70 million to purchase the land based on current property assessments for these parcels. Our understanding is that the budget does not include a contingency for rising property assessments if and when economic conditions improve.

Although the bulk of the elevated guideway and stations will be built over public streets and right of ways, land acquisition along these areas will still be required because of the width of the guideway and of the stations. The proposed specification of "hot" third rail technology requires that the train rails be grade-separated (moved above ground level) for safety. Since the most cost-efficient way to grade-separate third rail systems is to pair two lanes of rail together on an elevated guideway, this means that the guideway is double-wide throughout its length, and any stations require additional platform space on both sides of this double-wide dimension. Land acquisition is typically required at the stations, which will be 50 feet wide by 300 feet long[8].

Land Acquisition Costs: At-grade Rail

Although LRT systems are installed at grade, land acquisition costs are not necessarily higher than those for an elevated rail system. At-grade guideways (rails) are typically installed in existing roadways and the turning radius of at-grade LRT is normally accommodated in existing street right-of-ways. At-grade stations require only a widened sidewalk area (approximately 6 x 150 feet) on one side of the guideway. At-grade rail routes and station locations can offer planners and designers more flexibility compared with elevated rail systems which must account for large structural columns that can only be placed in the centerlines or outside of streets. At-grade rail lines can be paired on the same street or separated and put on different streets to minimize surface traffic disruption and further minimize the need for land acquisition.

Construction Time: Elevated Rail
According to the city, the estimated construction time for the first phase (20 miles) of the Honolulu system is 9 years, with construction to begin in December 2009 and full service to Ala Moana starting at the end of 2018[9].

Construction Time: At-grade Rail
Construction time for an at-grade LRT system in Honolulu would likely be similar to the system just completed in Phoenix. The 20-mile at-grade system in that city was completed in 4 years (2004-2008)[10].

Construction Energy Consumption
According to the Draft EIS for the HHCTCP, "construction of at-grade high capacity transit systems generally require 20,000 MBTUs of energy per track mile (Caltrans 1983), including track and power systems". For an all-elevated system such as the one proposed for Honolulu, "an additional 150,000 MBTUs of energy per track mile would be required to construct the elevated structure"[11]. Total energy required to build a mile of elevated rail line is 170,000 MBTUs, or 8.5 times the energy required for the same length of at-grade rail.

SUMMARY: CONSTRUCTION COST, TIME AND ENERGY
Comparing the latest City estimate for elevated rail ($5.3 billion) with the uppermost estimated cost for at-grade rail ($2.5 billion), a 20-mile at-grade LRT system would allow the City to build a transit system for one-half the cost, thereby reducing taxpayer funding. Comparing construction time of the Phoenix at-grade system (4 years) with the City's estimated construction time for Honolulu (9 years), at-grade LRT would allow the City to build a transit system in less that one-half the time, thereby reducing necessary traffic disruptions during construction. Finally, as energy costs and consumption have come to the attention of the public in light of global warming concerns, it is important to note that the embodied (construction) energy required for a mile of elevated rail is 8.5 times that of at-grade rail.

II. OPERATING AND MAINTENANCE COSTS (OMC)

Elevated Rail
According to the City's rail transit website, the annual operating and maintenance costs (OMC) for the proposed 20-mile elevated route will be $63 million[12], or $3.15 million per mile. This figure can be broken down into track-and-train OMC (which are the same whether at grade or elevated) and OMC associated with an elevated system. According to the Light Rail Industry (LRI), the typical OMC for an at-grade LRT system is $1.5 million per mile, or $30 million for a 20-mile system. Using a 1.3 cost multiplier to account for Honolulu's relatively higher cost of living, we estimate that the projected OMC for tracks and trains alone in Honolulu would be $39 million. Subtracting that figure from the City's overall OMC figure of $63 million leaves $24 million, which is the OMC for elevators, escalators, lighting, painting, restrooms, and security at elevated stations.

At-grade Rail
At-grade rail typically shares existing roadway and right-of-ways resulting in significantly lower OMC than elevated rail. No stairs, escalators or elevators are required. Steel rails are recessed

into existing streets so that track and station cleaning can be done as part of normal city cleaning and maintenance programs. At-grade stations consist of widened sidewalk platforms with roof structures and ticket vending machines. Lighting and security needs at at-grade stations are minimal since they can be monitored by existing police patrols and lit by existing streetlights. The 20-mile, 28-station at-grade LRT system which opened in Phoenix in December 2008 has an annual OMC budget of $31.6 million ($24 million for operations + $7.6 million for maintenance), for a unit cost of $1.58 million per mile[13].

SUMMARY: OPERATING AND MAINTENANCE COSTS

Compared with an elevated rail system, a 20-mile at-grade LRT system could save the City $24 million in annual operating and maintenance costs, and thereby further maximize use of taxpayer dollars.

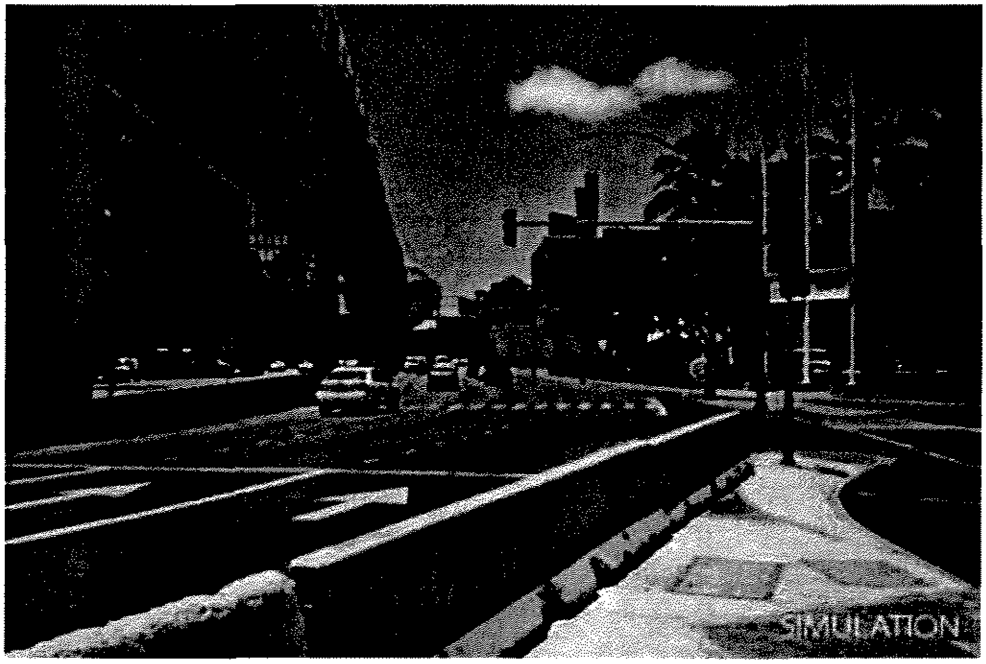
III. VISUAL AND ENVIRONMENTAL IMPACTS

Elevated Rail

The proposed elevated rail system will have "moderate" to "high" impact, according to the Draft EIS, on several neighborhoods through which it is proposed to run[14]. The guideway and stations will have two types of visual impact: blocking existing views, particularly in mauka-makai directions, and being a visual element out of scale and character with the immediate neighborhood. Mauka-makai view corridors are considered a critical part of the urban landscape of Honolulu and are protected under the City's Primary Urban Center Development Plan of 2004. Existing mauka-makai views in the immediate vicinity along the full length of the system will be significantly impacted. Views from existing apartments near the guideway will also be impacted, particularly in units on the lower four or five floors.

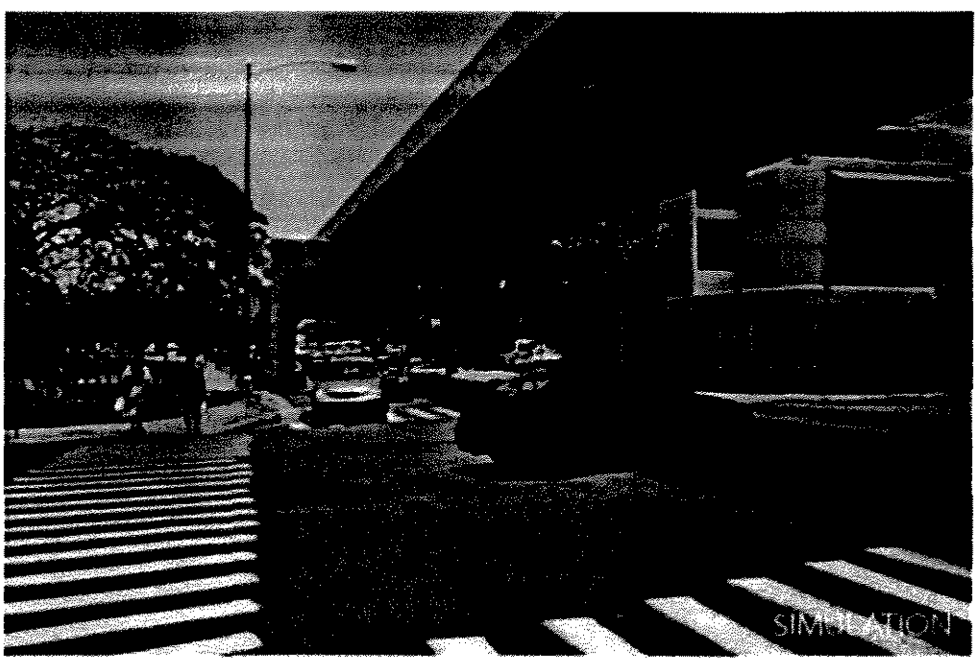
There will be high visual impacts in Downtown Honolulu, where the views down Bishop Street and neighboring streets to Honolulu harbor will be partially blocked by the elevated guideway and its support columns. The Chinatown district, with its historic connection to the waterfront, will be significantly impacted by an elevated concrete structure running the full length of the district.

The proposed elevated rail system is contrary to waterfront planning in leading cities throughout the world. Cities such as San Francisco, Boston, Seattle and Sydney have in recent years removed elevated transit structures separating their neighborhoods from the urban waterfront. An elevated rail line adjacent to the waterfront in Honolulu will create a physical and visual barrier between the waterfront and the Downtown/Chinatown area, as can be seen in the following simulation from the DEIS (Figure 4-32, Page 4-80):



Simulation of guideway at Nimitz Highway/Fort Street Intersection

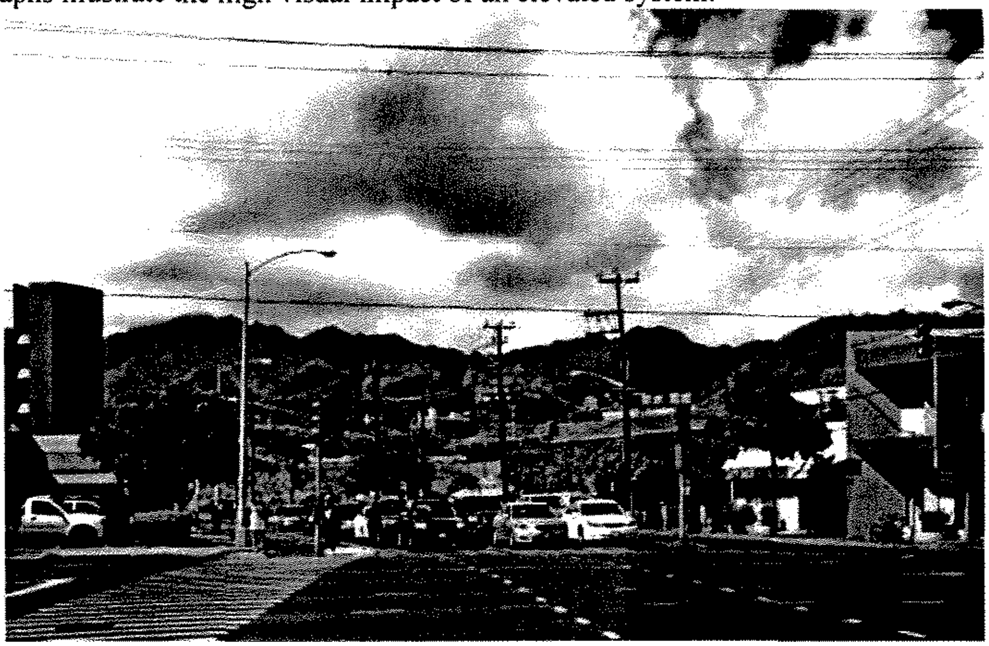
East of the Downtown area, Mother Waldron Park, a state Historic Site, and adjacent low-rise residential buildings will be substantially contrasted by the bulk and scale of the elevated guideway and required straddle bent structure, as seen in this simulation:



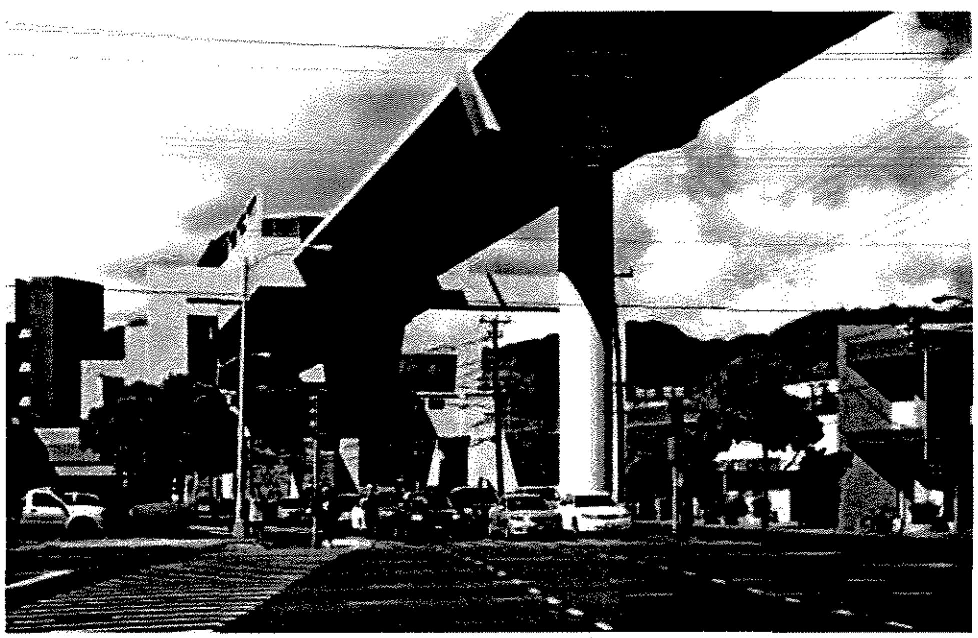
Straddle bent guideway and columns at Halekauwila Street/Cooke Street intersection

The second phase of the project (extending to UH Manoa), calls for a **double-decked guideway** between Pensacola Street and Ala Moana Center, further blocking mauka-makai views[15].

Phase 2 of the City's proposed system includes a 2-mile extension to UH Manoa. The following photographs illustrate the high visual impact of an elevated system:



Existing view, intersection of King Street & University Avenue, looking mauka



Simulation of proposed guideway and station, King Street & University Avenue

The sounds from trains passing every few minutes will impact those people working or living in the immediate vicinity of the route. The noise impact will be most severe for apartment dwellers living on the 3rd to 5th floors due to proximity of the guideway. However, there will also be noise impacts on floors above the guideway because the low buffer walls which are planned to block train noise will divert the noise upward.

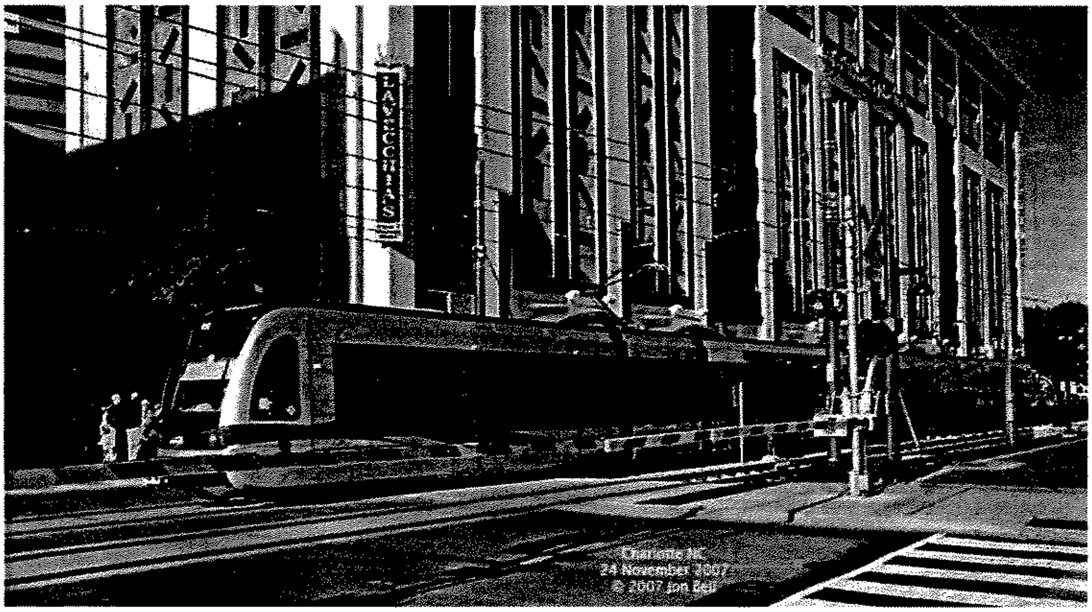
Construction of an elevated rail line will significantly alter the immediate environment under the entire length of the system. Construction down the center of existing divided streets will require the removal of many mature street trees. There will be a major loss of greenscape in these areas, as the street is changed from one with a center boulevard of grass and mature trees to one with a center hardscape in permanent shadow.

Construction of an elevated rail line in the urban core will create a more seriously degraded environment than in suburban areas. Urban core land underneath elevated transit structures such as highways and off-ramps tend to be paved, noisy, dusty and unpleasant for pedestrians. These environments often become favored locations for criminal activity such as drug-dealing and for the homeless.

Honolulu is a world-class tourist destination attracting millions of visitors every year who enjoy the exotic scenery and unique culture of Hawaii. An elevated rail structure in the urban core would have a detrimental effect on tourism, the primary industry in the state. The Waikiki Improvement Association has stated publicly that it has "serious concerns with a potential Waikiki spur from Kapiolani Boulevard …to Kuhio Avenue" because of "aesthetic and physical density issues of locating the overhead track in a resort and residential area"[16]. As can be seen in the photographs of the King Street/University Avenue intersection , an elevated system will block existing mauka-makai views and create a visual element out of scale and character with the surrounding community.

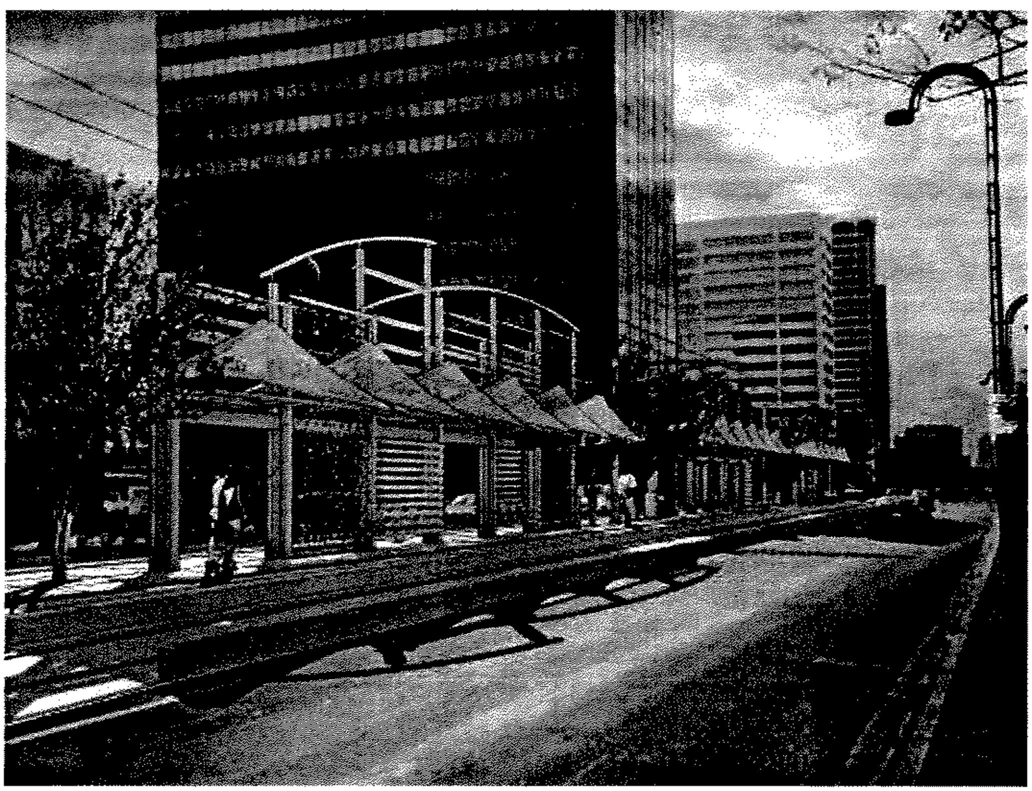
Due to the significant visual impacts of an elevated rail system, we are concerned that proposed mitigation measures will only have a marginal effect. Aside from broad statements such as "develop design guidelines" and "coordinate with the DPP", the only mitigation measures discussed in the DEIS are "provide new vegetation" and "shield exterior lighting"[17].

At-grade Rail
In cities where subway systems are not feasible, at-grade rail has consistently been the preferred rail alternative in the last 30 years in the United States. The popularity of at-grade rail is in large part due to the low visual and environmental impact on the existing urban fabric. Grade level guideways are virtually invisible in a street except for the rails recessed into the roadway and the thin power wire overhead, as seen in the following photo of the Charlotte (NC) light rail system:



LRT street crossing in Charlotte, NC

Grade level stations are minimal in visual impact, consisting of an open platform, roof structure and ticket machines, as seen in this view of the Phoenix light rail system:


LRT street median station in Phoenix, AZ

While the Phoenix example is of a median (center-of-street) station, at-grade rail can also be located on the outer lane of existing streets, allowing existing boulevard landscaping and trees (an important feature on streets such as Kapiolani Boulevard) to remain intact. At-grade guideways can also be split into one-way streets to minimize at-grade traffic impacts. An independent transportation consultant has noted that "the requisite through-put (capacity) could be achieved in Honolulu by reserving one curb lane on each one-way street for light rail transit operations with station areas located on the sidewalk"[18]. This idea is consistent with a previous plan by the City to place rail transit lines on King Street.

Sound impact on neighboring apartments is substantially less that elevated rail because an at-grade guideway is 30 to 40 feet farther from (below) apartment units located on upper floors. Steel-on-steel noises are reduced with at-grade construction due to sound conduction into the surrounding soil. Most importantly, existing urban neighborhoods traversed by at-grade rail retain their existing scale, character, daylight patterns, and greenscape.

SUMMARY: VISUAL AND ENVIRONMENTAL IMPACTS

Flexible technologies such as at-grade LRT offer transit planners the ability to pose far fewer visual and environmental impacts compared with elevated rail systems. By eliminating the bulk of the environmental impacts discussed in the DEIS, community concerns can be greatly reduced and public support further expanded. The scarcity of all-elevated rail systems currently being built in the United States suggests that other municipalities have sought to avoid the frequently severe environmental impacts (and high costs) of such systems. Even with the most sensitive design guidelines and coordination, it is difficult to prevent elevated rail systems from becoming an overpowering element in any urban environment. Flexible, at-grade rail systems, on the other hand, more easily blend into the existing landscape and urban fabric.

IV. TRANSIT-ORIENTED DEVELOPMENT (TOD)

Introduction

Transit-Oriented Development (TOD) has no universal working definition throughout the country but is typically defined as compact, mixed-use development near transit facilities with a high-quality walking environment.

The potential benefits of TOD are social, environmental, and fiscal. Focusing growth around transit stations leverages public investment in transit to encourage local investment, which leads to increased business and tax revenues. TOD, proponents believe, can be an effective tool in curbing sprawl, reducing traffic congestion, and expanding housing choices. The most direct benefit of TOD is increased ridership and the associated revenue gains. Research shows residents living near stations are five to six times more likely to commute via transit than are other residents in a region. Other primary benefits include the revitalization of declining neighborhoods, financial gains for joint development opportunities, increases in the supply of affordable housing, and profits to those who own land and businesses near transit stops.

TOD's secondary benefits include congestion relief, land conservation, reduced outlays for roads, and improved safety for pedestrians and cyclists. Many of these benefits feed off of each other. TODs help create compact, walkable communities, and provide sustainable, comfortable transportation while greatly reducing oil use. Walkable communities in turn support rail systems by providing high ridership.

Elevated Rail

Although any rail system is compatible with TOD, an elevated rail system tends to limit the full potential of TOD by separating the most important feature – the pedestrian-friendly walking environment – from the street. An elevated rail system moves all transit-related traffic and activity to 30 feet or more above the street, leaving existing businesses and buildings out of the action and creating a 30 to 50 feet wide shadow zone below that is pedestrian-unfriendly. Although TOD can occur around the stations of an elevated system, development tends to be confined mainly around the entrances to the stations since transit riders will not be inclined to linger in the areas below the guideway and stations.

At-grade Rail

At-grade rail systems can offer transit planners and communities much greater likelihood of realizing successful transit-oriented development by encouraging the following key characteristics:

Accessibility and Safety

All riders of rail transit start and end their trips as pedestrians. A pedestrian environment in which the trip to a station is safe and easy is important for encouraging transit ridership. With at-grade rail, the route for the pedestrian between station and destination can be short and direct with a minimum of stairs and grade changes. For riders in wheelchairs, on crutches, or pushing baby carriages/strollers, getting on and off a low–floor train from a sidewalk platform is much easier than getting to a train on a platform 40 to 80 feet above the street. At-grade stations can be more frequently located than elevated stations, which means better and easier accessibility for riders, which in turn promotes higher ridership. Higher ridership leads to higher usage of adjacent businesses and increased tax revenues for the city.

Safety and security are important to transit riders. With at-grade rail, riders are able to take a variety of routes as they walk to and from stations. The random pedestrian pattern generated by at-grade rail systems leads to more overall street activity and a safer street environment. Buildings and businesses adjacent to stations and guideways provide "eyes on the street" and informal security. Conversely, the elevators required by an elevated rail system are mostly avoided at night due to security issues and have maintenance problems due to vagrants using them to sleep and urinate.

Efficiency

Successful TOD must be mixed-use, location-efficient development that balances the need for sufficient density to support convenient transit service with the scale of the adjacent community. Successful TOD projects also cater to a range of income levels of users. With at-grade rail, the potential for an upgraded pedestrian experience extends outward in all directions from the stations because pedestrians walking from at-grade stations will take the most direct route to their destination. This widespread pedestrian traffic pattern associated with at-grade rail stations raises the development potential of the entire neighborhood which encourages not only new construction but rehabilitation of older buildings as well. The wider diversity of projects attracts a wider range of residents and neighborhood users of all income levels.

Community and Inter-modal Connectivity

At-grade rail allows planners to better utilize adjacent land uses, since no space has to be blocked out or condemned for escalators, elevators, structural columns, etc. At-grade stations can be located for easy access to the local community and interconnection with existing local businesses and services. Passengers on trains at-grade can easily connect to other modes of public transport such as buses or taxis.

Liveliness and a "Sense of Place"

At its core, transit-oriented development strives to make places work well for people. TOD aims to restore many of the features of yesteryear's cityscapes—comfortable and enjoyable streetscapes, vibrant and interactive public spaces, and an assemblage of land uses that invite people to stroll, linger, and interact with each other. At-grade rail stations can be designed to complement existing civic spaces such as plazas, waterways, public malls or parks. There is a growing appreciation for the need to create enduring main streets and real places in American cities. Creating stations with a "sense of place" seems particularly important in Honolulu, which prides itself on being a unique destination in the United States.

SUMMARY: TRANSIT-ORIENTED DEVELOPMENT

In many ways Transit–Oriented Development seeks to reproduce the cityscapes found in American cities some 80 years ago: city streets full of pedestrians from all walks of life, sidewalks comfortable and enjoyable for a stroll and stopping to talk with fellow residents, attractive civic spaces interspersed throughout. Like the streetcar systems common in American cities in the 1920's, at-grade rail has significant advantages for TOD in areas of accessibility, safety, efficiency, inter-modal connectivity and overall neighborhood liveliness. At grade LRT can offer transit planners and the communities they serve greater opportunities to create a successful TOD not available to planners of elevated rail.

V. AT-GRADE TRAFFIC IMPACT

Elevated Rail

With most functions raised 30 - 40 feet above street level, at-grade traffic impacts of elevated rail are primarily the result of placement of structural columns at the street level to support the guideway and stations. Where the guideway is centered on an existing street, columns will take up one traffic lane. On boulevard-type streets, guideway columns can fit within existing median strips and have little impact on traffic. Where columns are located at the sides of streets to hold up straddle-bents at stations, there will be a loss of sidewalk space.

The impact on at-grade traffic by elevated rail will be particularly severe during construction of the system. Excavation for column foundations and utility relocation will be more extensive with elevated rail than for at-grade rail, requiring larger portions of existing streets to be closed. Overall construction time for elevated rail will be twice as long as that for at-grade rail, requiring longer closure of existing streets and longer periods of impact on at-grade traffic.

At-grade Rail

At-grade traffic impacts have been cited by the City administration as a key reason for the selection of an elevated rail system. The City's engineers have set design criteria for the system at 6,000 pphpd (passengers per hour per direction) capacity, with 3 minute intervals (headway) between trains, and they have stated that it is not possible to put such a system on Honolulu streets without a major increase in traffic congestion.

However, we respectfully offer differing information for further consideration. According to independent traffic engineers, "achieving a capacity of 6,000 pphpd with 3-minute headways is easy to do with a light rail transit running on surface streets. 3 minute headways equate to 20 trains per hour, (with each train) having a capacity of 300 passengers (20 trains x 300 passengers = 6,000 pphpd)"[19]. Furthermore, modern light rail vehicles, such as the Siemens S70, have a capacity of 232 passengers per car. Each car is 95 feet long, meaning a 2-car train would be 190 feet long or well within the length of a typical Honolulu city block (250 – 400 feet) and out of the way of cross traffic. A system using 2-car trains of the Siemens S70 type would have a capacity of 9,280 pphpd (464 passengers x 20 trains = 9,280 pphpd), or more than 50% beyond the required 6,000 pphpd criteria.

Working examples of this type of system can be found in cities such as Charlotte, Dallas, Denver, Houston, Phoenix, Portland, Sacramento, and San Diego. Rail car manufacturer selection is not limited to Siemens; several other companies such as Alstom, Bombardier, CAF, and Kinki-Sharyo make comparable equipment such as this low-floor model used in the new Phoenix LRT system:

Phoenix LRT car manufactured by Kinki-Sharyo

According to independent traffic consultants contacted by AIA Honolulu, at-grade traffic impact is a concern with at-grade rail but is not a serious problem when combined with a signal synchronization system and/or a traffic preempt system. A traffic preempt system alters signals at intersections to give priority to any train approaching the intersection. Successful examples of this include Portland TriMet's MAX light rail where design policy permits trains to only stop at stations to prevent traffic delays[20].

Pedestrian safety is also a concern when locating at-grade rail lines and stations. At-grade trains can be put in exclusive-use lanes or pedestrian malls to protect passengers from at-grade traffic as they disembark. Pedestrian barriers are also used, particularly in median (center street) stations to force pedestrians to slow down and take notice as they approach traffic lanes or intersections.

SUMMARY: AT-GRADE TRAFFIC IMPACT

At-grade LRT systems can offer transit planners a viable alternative to elevated rail while still maintaining transit system design criteria for passenger volume and train frequency. Impact on at-grade traffic can by managed through signalization systems commonly used in 35 other cities. Similarly, pedestrian and passenger safety can also be maintained via barriers and protected zones.

AT--GRADE RAIL REFERENCES

1. www.lightrail.net
2. www.lightrailnow.org
3. www.valleymetro.org (Phoenix light rail system)
4. www.calgarytransit.com (Calgary, Canada light rail system)
5. www.lrta.org (Light Rail Transit Association)
6. www.dart.org (Dallas Light Rail)
7. Note: The LRT systems listed in Appendix 1 all have individual websites with detailed information, schedules etc. Website addresses can be found by search engine, typing in the city name and the words "light rail".

TOD REFERENCES

8. *TCRP Report 102 Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects*, Transportation Research Board of the National Academies, Transit Cooperative Research Program; Sponsored by the Federal Transit Administration, Washington, D.C. 2004,
9. *9th National Light Rail Transit Conference, Experience, Economics & Evolution – From Starter Lines to Growing Systems*, Transportation Research Circular, Transportation Research Board of the National Academies, Number E-CO58 November 2003.
10. *Transit Oriented Development: Moving from Rhetoric to Reality*, A Discussion Paper Prepared for The Brookings Institution Center on Urban and Metropolitan Policy and The Great American Station Foundation, June 2002.
11. *Transit-Oriented Development: The Portland Planning Experience*, Debbie Bischoff, Senior Planner Portland Bureau of Planning, City & County of Honolulu TOD Public Workshop, July 14, 2007.
12. *Transit-Oriented Development Best Practices Handbook, City of Calgary Land Use Planning & Policy Department,* January 2004.

End Notes

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1. Honolulu Advertiser, Dec. 25, 2008, Page A1, "Isle voices raised on rail line", article by Sean Hao.

2. H-3 was originally envisioned to cost $250 million; the final cost was $1.3 billion (Honolulu Advertiser Aug. 28, 2007, page A16, article by David Johnson).

3. 29 systems are in the United States; 3 each are in Canada and Mexico. Reference website: www.lightrail.org/success1.htm.

4. "North American Light Rail & Trolley Systems"; www.lightrail.net/LRTSystems.htm

5. Construction cost multipliers were taken from two different professional cost estimators (Riders Digest – 1.38, and Victor Tsuha/Cost Engineering – 2.2) and averaged, for a multiplier of 1.79 for converting Phoenix construction costs to Honolulu costs.

6. Honolulu Advertiser, April 20, 2008, Page A1, "Rail line will alter city's landscape", article by Sean Hao. Typically, the proposed guideway will range from 30 to 50 feet above ground level, with high points at Waiawa Stream (90 feet above grade), Ala Moana Center station (86 feet above grade) and King/University station (60 feet above grade).

7. Honolulu Advertiser, June 1, 2008, Page A1, "189 properties in rail's path", article by Sean Hao.

8. Honolulu Advertiser, December 25, 2008, Page A1, "Isle voices raised on rail line", article by Sean Hao.

9. Ibid.

10. Honolulu Advertiser, December 28, 2008, Page A25, "Phoenix commuters applaud startup of light rail system", article by Jacques Billeaud (Associated Press)

11. DEIS, Chapter 4, page 4-159.

12. Information from www.honolulutransit.org/faqs

13. Correspondence from John Farry, Director of Community Relations, Phoenix MetroRail, January 20, 2009.

14. DEIS, Chapter 4, page 4-62.

15. DEIS, Appendix A, Sheet RP024. In the profile drawing at the bottom of the sheet, a second guideway labeled "Future Extension" is shown above the (Phase 1) guideway ending at Ala Moana Center.

16. Comments on the DEIS submitted by the Waikiki Improvement Association, December 15, 2008, page 7.

17. DEIS, Chapter 4, page 4-93.

18. Correspondence from Philip G. Craig, Railway system designer/ Transportation Consultant since 1955, Upper Montclair, NJ , January 20, 2009.

19. Correspondence from Philip G. Craig, Transportation Consultant, Upper Montclair, NJ, January 21, 2009.

20. Information taken from Portland LRT website: www.trimet.org/about/history.htm

APPENDIX 1
AT-GRADE LRT SYSTEMS IN OPERATION IN NORTH AMERICA

City	Oper. Date	Total Const. Cost	Length (mi)	Const. Cost/Mi.	# of Stations
1. Baltimore	1992	N/A	29	N/A	32
2. Boston/Grn line	1888	N/A	25.6	N/A	78
3. Buffalo	1984	N/A	6.4	N/A	15
4. Camden NJ	2004	$1B	34.5	$25M	20
5. Charlotte NC	2007	$462M	9.	$48.2M	15
6. Cleveland	2000	N/A	15.4	N/A	27
7. Dallas/NC line	2002	$1B	24	$46M	14
8. Denver	1994	N/A	39.4	N/A	36
9. Houston	2004	$324M	7.5	$43M	16
10. Jersey City	2001	$992M	9.6	$103M	30
11. Los Angeles	2003	$859M	13.7	$65M	13
12. Memphis	2000	N/A	4.6	N/A	(Streetcar)
13. Minneapolis	2004	$715M	11.6	$60M	17
14. Newark	1935	N/A	4.3	N/A	12
15. Philadelphia	1892	N/A	42.5	N/A	64
16. Pittsburgh	2002	$386M	5.2	$74.2M	8
17. Portland OR	1986	N/A	44	N/A	47
18. Sacramento	2003	$222M	6.3	$35M	10
19. St. Louis	1993	N/A	46	N/A	28
20. Salt Lake City	2004	$520M	19.5	$56M	23
21. San Diego	2000	$506M	5.9	$85.7M	11
22. San Francisco	1988	N/A	5.8	N/A	(Streetcar)
23. San Jose	2005	$320M	5.3	$60M	9
24. Seattle	2009	N/A	14	N/A	14
25. Tacoma	2003	$80.4M	1.6	$50M	5
26. Phoenix	2008	$1.4B	20	$70M	24
27. New Orleans	1998	N/A	7	N/A	(Streetcar)
28. Tampa	1995	$32M	2.3	$2.3M	(Streetcar)
29. Galveston	1988	N/A	5.2	N/A	(Streetcar)
30. Calgary (Can.)	1981	N/A	28	N/A	36
31. Edmonton (Can.)	1978	N/A	12	N/A	10
32. Toronto (Can.)	1892	N/A	46	N/A	N/A
33. Guadalajara (Mex)	1989	N/A	6.2	N/A	12
34. Mexico City (Mex)	1985	N/A	11.1	N/A	18
35.Monterrey (Mex)	1991	N/A	14.2	N/A	24

N/A: Information not available

APPENDIX 2

AIA Public Policy on Transportation

The American Institute of Architects/Honolulu Chapter supports funding and planning to integrate all transportation modes with an emphasis on alternatives to the automobile ***including*** mass transit, pedestrian ways, bicycle paths, and water transit so that each region and urban area may choose the most effective and efficient combination of modes for its own needs.

Supporting Statement

We encourage the use of social, environment, and aesthetic criteria—as well as economic efficiency—in the design of routes and supporting facilities for all transit modes.

Transportation system routes and facilities should support land use objectives, including urban growth management and efficient transit mode linkages, and respect significant human, cultural and natural environments.

Furthermore, transit systems and facilities should achieve the following design objectives:

A. Protect and enhance mauka-makai view corridors in accordance with the City & County of Honolulu's Primary Urban Center Development Plan (PUC DP) and Land Use Ordinance (LUO). Framed street views of the mountains and the shoreline are significant scenic resources that provide directional orientation to motorists, pedestrians, and visitors alike. Visual and physical access between mauka and makai should be preserved to enhance the connection between the city and the waterfront.

B. Preserve and enhance historic and cultural districts in accordance with the City & County of Honolulu's PUC DP and LUO. The planning and design of transit systems and facilities should complement the visual context of these areas as well as their physical, historic, and cultural value. Significant vistas associated with these structures and districts should also be retained.

C. Provide safe and healthy environments for transit passengers as well as pedestrians and neighborhood residents along the transit route. Safe and easy accessibility should also be promoted.

D. Promote sustainable planning, design, and operation. In keeping with sustainable practices, transit systems and facilities should offer the ability to meet present needs without compromising those of future generations.

The physical and aesthetic impact of new and improved road systems should be considered by planners. Road widths and infrastructure improvements should be kept to the minimum needed to accomplish transportation and community planning objectives.

AIA Position Statement on Transit

The American Institute of Architects supports funding, planning, design and implementation to integrate all transportation modes – including mass transit, pedestrian walkways, bicycle paths and water transit – so that each region and neighborhood will be served by the most effective and efficient combination of modes to meet its own needs.

AIA encourages the use of social, environment and aesthetic criteria – as well as economic efficiency – in the design of routes and supporting facilities for all transit modes. Transportation system routes and facilities should support land use objectives – including urban growth management and efficient transit mode linkages – and respect significant human, cultural and natural environments.

AIA Honolulu (The Honolulu Chapter of The American Institute of Architects) strongly supports the concept and implementation of a fixed guideway transit system as an integral part of the future plans to meet the needs our growing island communities.

At the same time, there are serious concerns about urban design issues and visual impacts on the surrounding neighborhoods. Our greatest concerns with the City's current plan are the elevated rail along Nimitz Highway through the Downtown core and historic Chinatown that will isolate the city from Honolulu's extraordinary waterfront, as well as elevated spurs to the University of Hawaii at Manoa and Waikiki.

AIA Honolulu strongly believes that we must implement a plan that protects the mauka-makai view corridors that are outlined by the City & County of Honolulu in its own Primary Urban Center Development Plan and Land Use Ordinance.

We believe that the ultimate solution is not just about the best engineering solution, but that priority needs to be placed on the planning and design of the overall transit system to sensitively serve the needs of the residents of Oahu and its visitors, while protecting the beauty of the unique environment in which we live, work and play. Moreover, we believe that good design, combined with comprehensive urban planning, is a critical investment in our future and that of our children. By degrading our island's visual environment with an overhead system through our Downtown and historic core, we would significantly decrease Honolulu's visual appeal as a place to live. In addition, as a resort destination, an elevated rail system through the Downtown corridor and into Waikiki could negatively impact our visitor appeal for the next century.

AIA Honolulu has enjoyed greater dialogue with the City on transit issues in recent months and hopes to assume an even greater role in collaborating with the Mayor, his administration, its consultants and the Honolulu City Council to insure critical design issues are addressed as this historic project moves forward.

At this juncture, we look forward to continuing to work with the City to examine alternatives to the elevated rail through the Downtown corridor along Nimitz Highway. In particular, AIA Honolulu asks that the City consider an at-grade (street-level) or below-grade (underground) fixed guideway system, or that the alignment through Downtown be shifted so that mauka-makai view corridors are preserved for future generations.

The American Institute of Architects Smart Growth/Transit Oriented Development Local Issue Brief

http://www.aia.org/SiteObjects/files/Transit%20Based%20Development_REV.pdf

Alstom Tram TECHNOLOGY PROVIDES EASE OF Integration

Alstom's Citadis tram fleet operated by Compagnie des Transports Strasbourgeois was adapted to the specific requirements of the city of *Strasbourg, France.*

- All photos courtesy ALSTOM Transport/TOMA - C. Sasso

Offering reduced energy consumption, low-noise technology, and a bevy of propulsion options, the Citadis tram fits easily into its environment.

>BY JANNA STARCIC, Executive Editor

WHEN PLANNING A TRANSPORTATION system, integration into its surroundings is key. **ALSTOM Transport's** Citadis tram technology was developed to mesh easily with various environments. Its multiple propulsion options, low-noise factor and modular design allow the vehicle to fit in just about anywhere.

STRASBOURG SYSTEM

The city of Strasbourg is located in the Northeastern portion of France near the border of Germany. Known for its architecture, the city's skyline features a towering gothic cathedral, as well as other medieval structures. While the city elicits an Old World aesthetic, it boasts one of the most well-connected transportation networks. One element of this network is the city's tram system. Operated by the **Compagnie des Transports Strasbourgeois** (CTS), the nearly 34-mile tram system has five lines and features 70 stations. Although the city's modernized tram system was launched in 1994, Citadis trams were added in 2005 to meet growing service demands. In addition, the system will go international in 2010 when it is extended to Germany.

The Citadis tram fleet, comprised of 41 trainsets, was adapted to the specific requirements of the Strasbourg environment. The low-floor vehicles were fitted with a small bogie at either end in order to follow the network's curves more smoothly and provide harmonious movement. Featuring a

France's Mulhouse-based tram system is another example of innovative design. The public had a hand in choosing the design (interior shown) during a public consultation.

nearly eight-foot width, the trams can carry 288 passengers.

MODULAR DESIGN

In addition to Strasbourg, numerous cities across the globe from Algiers to Valenciennes, France, have implemented Citadis tram technology. By combining standardization of components with customization of interior and exterior designs, the technology adapts to the requirements of each city in terms of aesthetics, comfort and accessibility.

"The whole concept was based on modularity and flexibility," says **Roelof van Ark**, president, **ALSTOM Transportation Inc.** and SVP, North America Region, ALSTOM Transport. Eighty percent of Citadis components are standardized. "Customers can choose the length of the tram, as well as decide on the nose or the cab section of the car and its styling," van Ark says. "Finally, you can choose your own colors or corporate patterns and designs."

Other options include video surveillance systems, as well as media displays. "You could show the news and you could also advertise," says van Ark. "You could offer passengers information updates about train delays, and other information that applies to the passenger."

When reviewing the portfolio of Citadis projects, several European systems stand out due to their progressive designs and use of color. "European designs have developed much further because the market is that much larger," says van Ark. "Therefore, you have many more options coming out of the European market." That's one of the reasons that the Citadis range has been a success, he adds. "The core business is important because that's where you develop your product."

Some progressive tram designs are on display in the French cities of Toulouse and Reims. To acknowledge its distinction as the "European hub of the aeronautics industry," the city of Toulouse designed the nose of each of its trams to reflect the shape of an Airbus airplane. For the latter system based in Reims—the capital of the Champagne region—the tram design was inspired by a champagne glass.

ENVIRONMENTAL CONSIDERATIONS

Because they use clean energy and can transport the same number of people as three buses or 50 cars, trams are considered an ultra-modern solution against pollution and congestion in cities, according to Alstom. In addition, the company is committed to integrating other environmental considerations in its tram design "to limit and reduce their impact on the environment throughout their life cycle, from construction to recycling."

"When the Citadis tram line was originally developed, the concept of recyclability was a significant factor," says van Ark. (There is a minimum recyclability rate of 85 percent.) "We spend a lot of energy and time in designing the cars to ensure that they can be recycled, says van Ark. "And we continue to do so." The company makes a point to integrate reusable materials into the tram design, including steel, aluminum and copper. In addition, the use of "biomaterials from renewable sources, such as wood and hemp" is also being researched.

It's also important that a big portion of other synthetics being used can be recycled, van Ark says. "There's a lot of effort made to use recyclable materials in the inner cladding, the seating materials and the synthetic materials, mainly inside these cars."

The company also uses composite materials, and has improved the Citadis' traction system's efficiency to help reduce energy consumption levels by 10 percent.

Each day, 40,000 people use the Mulhouse tramway, inaugurated in May 2006. The tram system is based in France near the German and Swiss borders.

In addition, Alstom has also lessened its impact on the environment through the reduction of noise emissions. With the use of insulation materials and acoustic dampeners, the system emits 5 dBAs less than automotive traffic. "That is four times less noise than you would have on a roadway with traffic on it," van Ark says.

PROPULSION OPTIONS

In keeping with its concept of integrating seamlessly into the environment, the company offers an array of propulsion solutions. In addition to the standard overhead catenary system, other power options include APS (ground-level power supply), battery power and two newer technologies in final development, the inertia flywheel and super capacitors.

The Citadis tram, with its lightweight design and low-noise technology, integrates easily into cities and can be mixed into traffic with automobiles.

The ground-level power supply system—or wireless APS (Alimentation Par le Sol) system as it is known—uses a third rail embedded in the tracks to supply power to the tram. "You can decide on the different propulsion technologies that you require," van Ark says, adding that catenary systems might not always be appropriate for some settings. "It's important not to bring catenary systems into cities with historic sites."

The city of Bordeaux, France, incorporated 9 miles of its 27-mile system with the APS-powered propulsion—the first in the world to install the technology, according to Alstom.

Battery power, another wireless option, can be utilized for small distances just over a half-mile. To help "preserve" the historical nature of the city's Place Masséna and Place Garibaldi squares, the French city of Nice employed battery power for its Citadis tram.

Still under development, the inertia flywheel system powers the tram through "recovering the energy released during braking."

A mixture of propulsion options can also be used to fulfill the system's needs. "You can use a standard catenary supply along with an APS, or the catenary system with the battery, or the battery system with the APS or the new propulsion systems," van Ark says. "It's very modular."

TRAM-TRAIN CONCEPT

Another tram offering based on the Citadis platform is Alstom's Dualis model. This version employs the capabilities of both a tram and a train. Vehicles can operate on a tram network, as well as on a regional rail network.

This configuration makes it a highly versatile means of transport: its tram build enabling it to run through the city, while its performance as a train allows it to transport passengers at over 60 mph once on the outskirts of cities, without the need to change the means of transport.

The tram-train concept was initially developed in Germany, where Alstom has put into service its Regio Citadis model, in Kassel. Developed at Alstom's Valenciennes facility in France, the first Citadis Dualis trainsets should enter service in January 2010 on the Nantes network and, in March 2010, on the Lyons network.

LATEST CONTRACTS

Looking to the future, Alstom's Citadis technology continues to expand its global reach with new projects on the horizon. Along with its partners, the company recently received two contracts from the Algerian public transport company EMA (Entreprise du Métro d'Alger) to supply "turnkey" tramway systems for the cities of Oran and Constantine. The contract for the city of Oran calls for an 11-mile line, serving 32 stations. Its value is worth $550 million, of which $229 million is allocated for Alstom. The **TRAMNOUR** consortium is made up of Alstom Transport and the Spanish group **Isolux CORSAN**. Alstom will supply 30 Citadis tramways, which will be manufactured at the group's factory in Barcelona, Spain. Alstom will also supply the operating system (signaling and telecommunications), as well as the depot equipment and the substations. The first trainsets will enter commercial service 26 months after the contract takes effect.

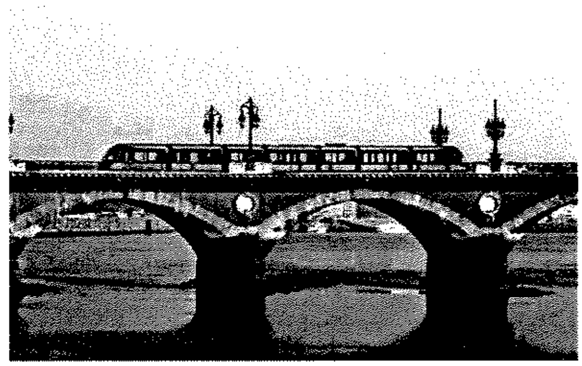
The Constantine contract, a 5-mile line serving 11 stations, is worth $475 million, with Alstom's portion totalling $276 million. Alstom will supply 27 Citadis tramways, the track, electrical power supply, operating system (signaling and telecommunications) and the depot equipment. The first trainsets will enter commercial service 27 months after the contract takes effect. m

APS
The street level power supply

> The principle

APS is a system to power trams without overhead catenaries, allowing the tram to operate « wire-free » over journeys of any distance and hence to blend into the urban environment.

APS is an Alstom exclusivity. The Communauté Urbaine de Bordeaux (Bordeaux Metropolitan Area) is the first city in the world to have opted for this completely new technology on 14 km of its 44 km long tram network. It has been operating since the end of 2003. In 2006, the French cities of Angers, Reims and Orléans have also chosen an APS solution.

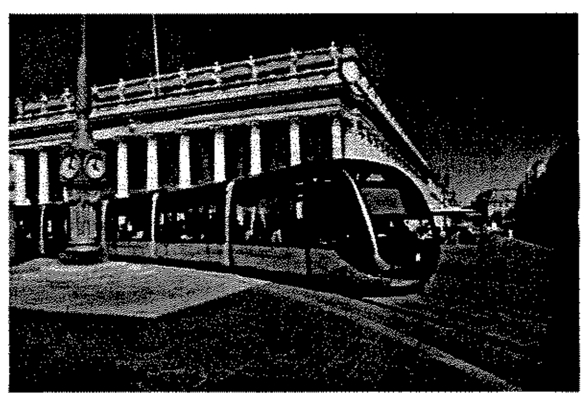


> How does it work?

Power is supplied to the tram through a third rail embedded in the tracks. This third rail is made up of 8 metre-long conducting segments, which can be powered, and which are separated by 3 metre insulating joints. Power is supplied to the conducting segments by underground boxes every 22 metres. The electricity transmitted through this third rail is picked up by two friction contactors located in the mid-section of the tram. The delivery of power to the conducting segments is triggered by coded radio dialogue between the tram and the ground, and only occurs once the conducting segment has been covered by the tram, ensuring total safety for pedestrians.

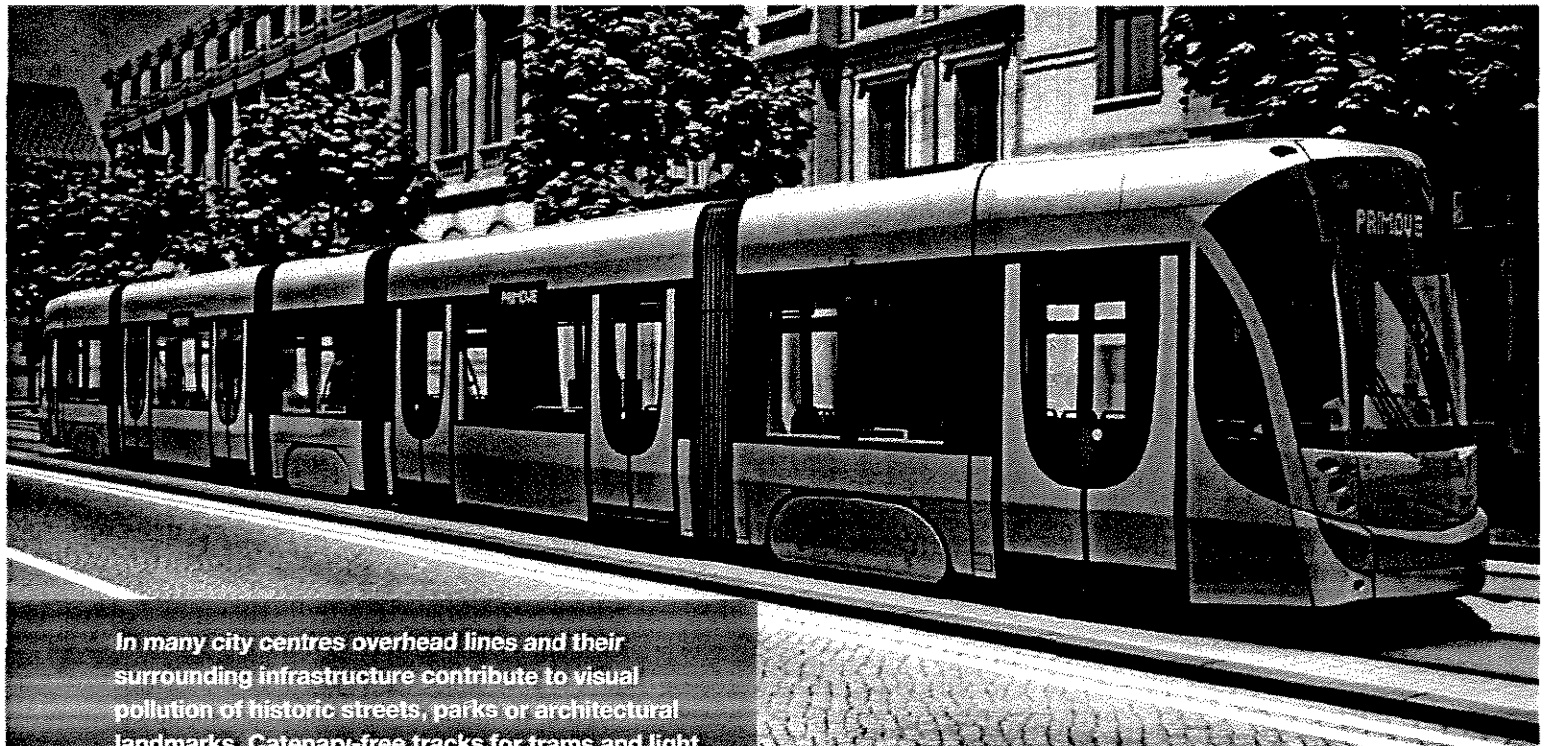
> The advantages

- Preservation of the urban environment and historical heritage
- Performance levels equal to those of a conventional tram in terms of comfort and speed
- Total safety for pedestrians and road users
- Compatibility with all types of road surface
- Easy extension of the system if the line is prolonged



EcoActive Technologies

PRIMOVE
Catenary-Free Operation



In many city centres overhead lines and their surrounding infrastructure contribute to visual pollution of historic streets, parks or architectural landmarks. Catenary-free tracks for trams and light rail vehicles heighten the attractiveness of a city and provide for unobstructed views.

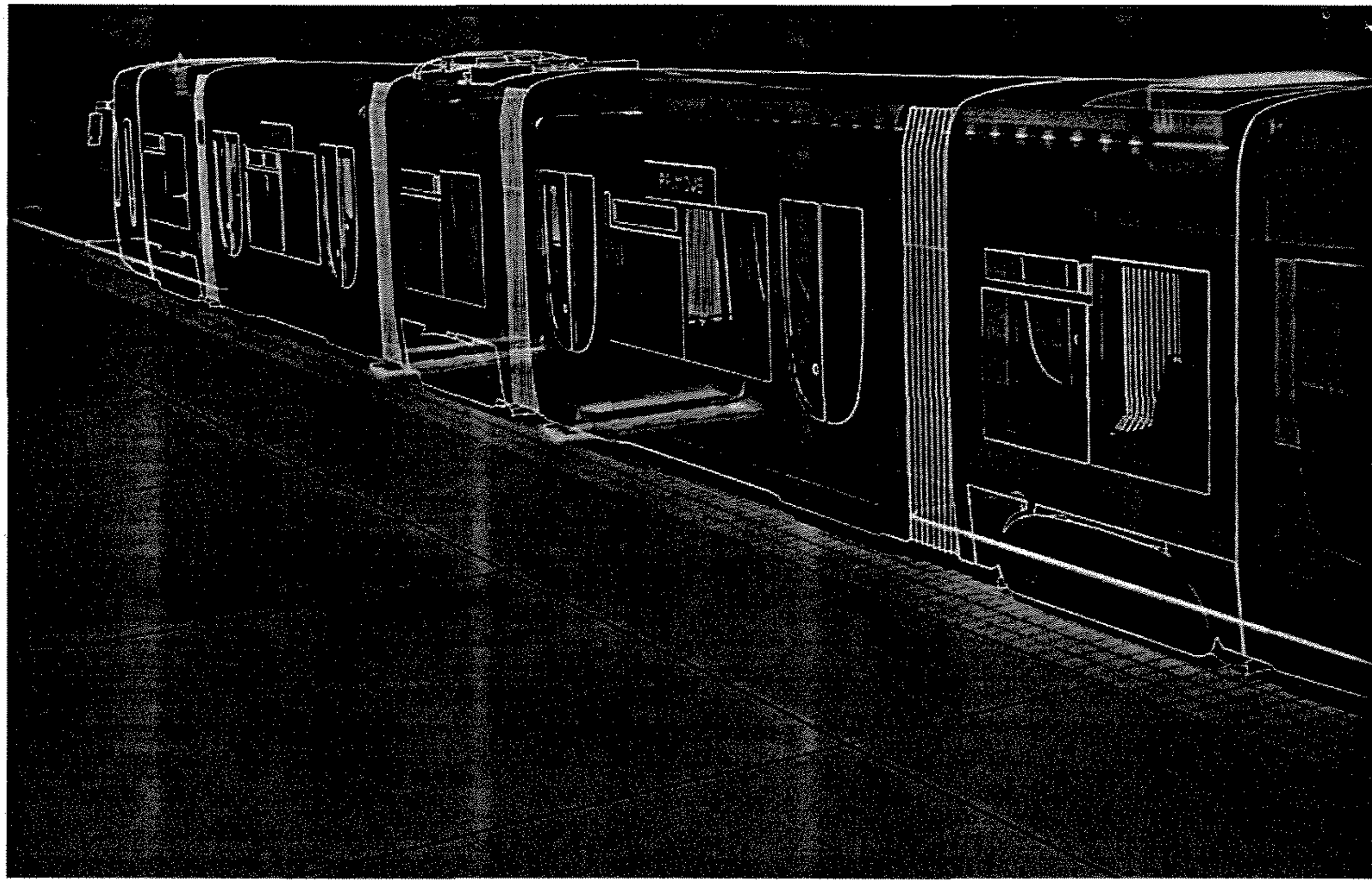
A world-premiere: contactless power transfer for urban rail vehicles

The new and unique *BOMBARDIER* PRIMOVE** system allows catenary-free operation of *FLEXITY** trams over distances of varying lengths and in all surroundings as well as on underground lines – just like any conventional system with overhead lines. What makes it outstanding is that the power transfer is contactless; the electric supply components are invisible and hidden under the vehicle and beneath the track.

The benefits are evident:

- Elimination of overhead wires – increasing a city's attractiveness
- Safe inductive power transfer
- No wear of parts and components
- Resistant to all weather and ground conditions including storms, snow, ice, sand, rain and water

The *PRIMOVE* system is connected to the *BOMBARDIER* MITRAC** Energy Saver, which stores electrical energy that is gained during operation and braking on board the vehicle by using high-performance double layer capacitor technology. Doing so optimizes power supply and saves energy.



Catenary-free operation – energy flow

Bombardier is at the forefront of continuously improving rail transportation as an ecologically leading mode of transport

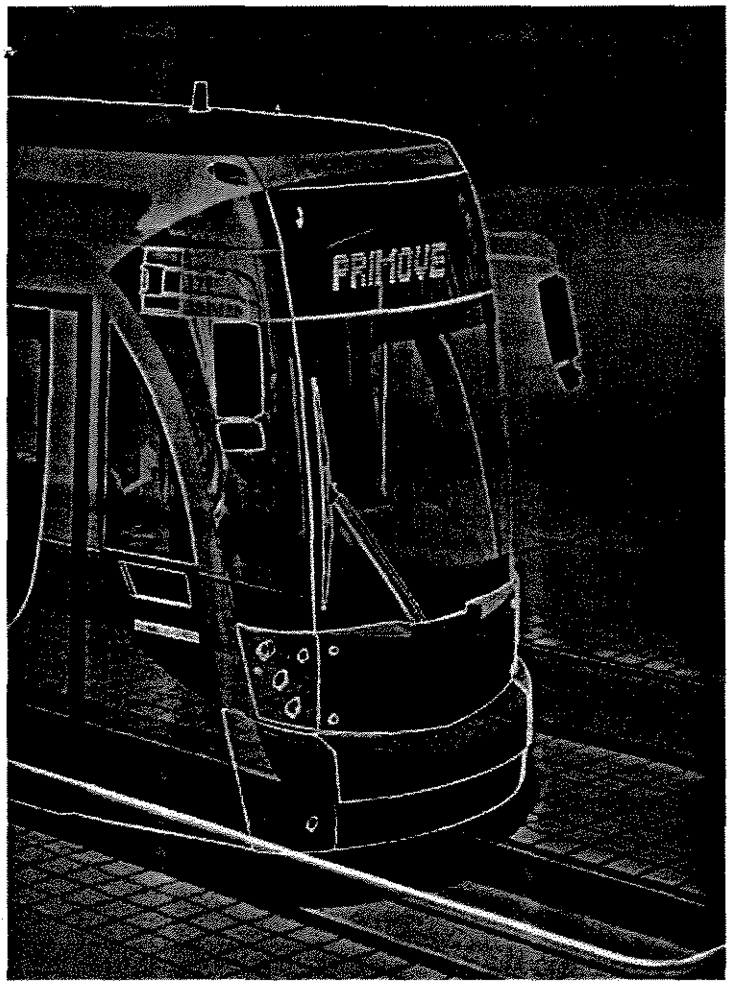
Preserving our environment by reducing emissions and using energy resources in an efficient and responsible way are undoubtedly major challenges which communities all over the world face today. Exhaust emissions and noise are some of the main factors that lead to a deterioration in the quality of life in our cities. In urban transport, railbound operations are making a major contribution to relieving congestion as well as cutting CO_2 and noise emissions.

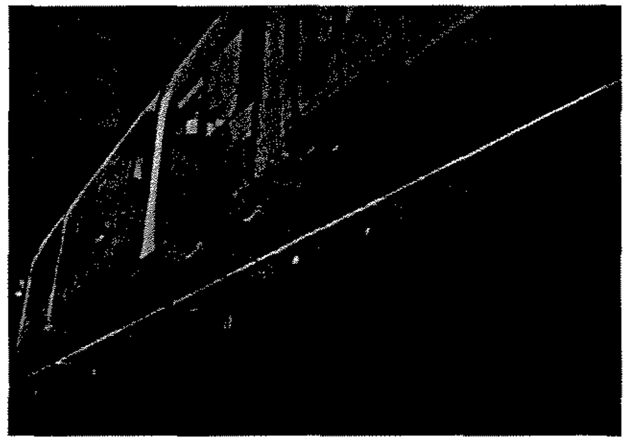
Why Catenary-Free operation?

In addition to these well-known factors, municipal authorities are increasingly facing visual pollution caused by power poles and overhead lines obstructing the visibility of landmark buildings and squares. With *PRIMOVE* catenary-free operation trams can even run through heritage-protected areas, such as parks and gardens, historic market and cathedral squares, where conventional catenary systems are not permitted, thus preserving natural and historic environments. Additionally, when planning a new system or extensions catenary-free operation will contribute to an attractive and forward-looking appearance.

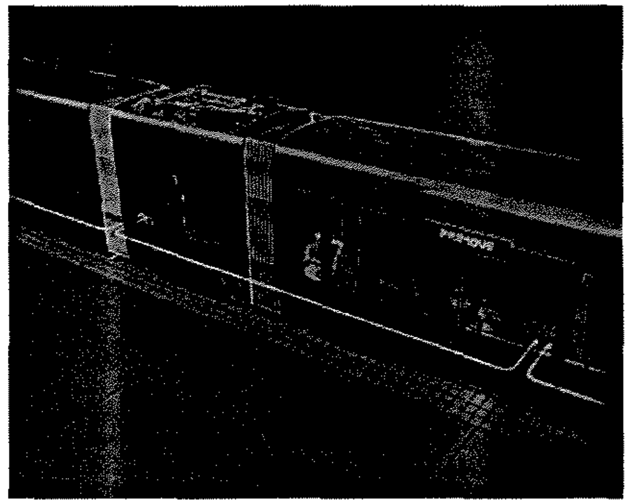
PRIMOVE Catenary-free operation – safe, cost-efficient, reliable and flexible:

- Due to invisible and contactless power supply, operation of the *PRIMOVE* catenary-free system is safe for pedestrians and other road users such as bikes, motorbikes or cars
- With no direct contact during energy transfer there is no wear of parts and components which keeps service and maintenance costs at a minimum – the initial construction costs lie far below those of any comparable solution on the market
- Reliable performance in all weather and ground conditions
- Same vehicle performance as with conventional catenary systems
- With the on-board *MITRAC* Energy Saver the system can continuously recharge the energy levels needed for uninterrupted maximum performance
- The *PRIMOVE* system can be tailored to the individual needs of each city: it is adaptable to different topographical conditions, performance expectations and distances





Pick-up coils



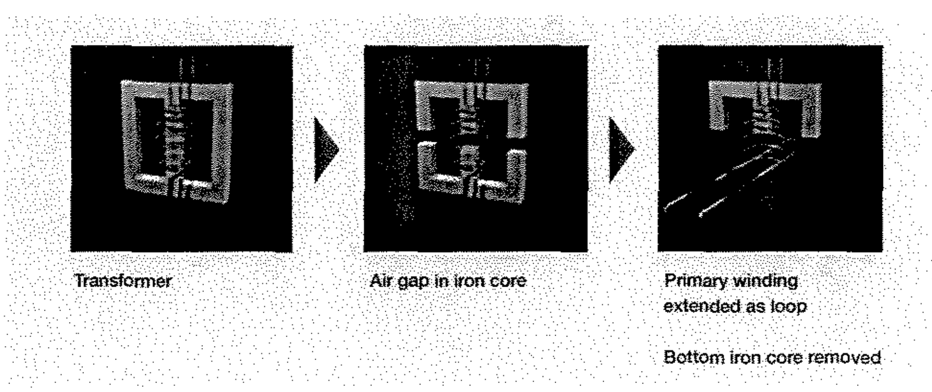
Underground cables

How does the PRIMOVE system work?

When running on conventional systems, trams and light rail vehicles take their energy from an overhead electrical line. Equipping the tracks and the vehicle with the *PRIMOVE* components also allows operation without a catenary. Cables laid beneath the ground are connected to the power conditioning and supply network. They are only energized when fully covered by the vehicle, which ensures safe operation. A pick-up coil underneath the vehicle turns the magnetic field created by the cables in the ground into an electric current that feeds the vehicle traction system.

Inductive power transfer principle

The functional principle is based on the inductive power transfer of a transformer (see illustration below) – a principle that is up to now has only been used in certain industrial applications (in the automotive industry for transportation systems in manufacturing) or with household appliances (i.e. electric toothbrush).



Working principe – inductive power transfer

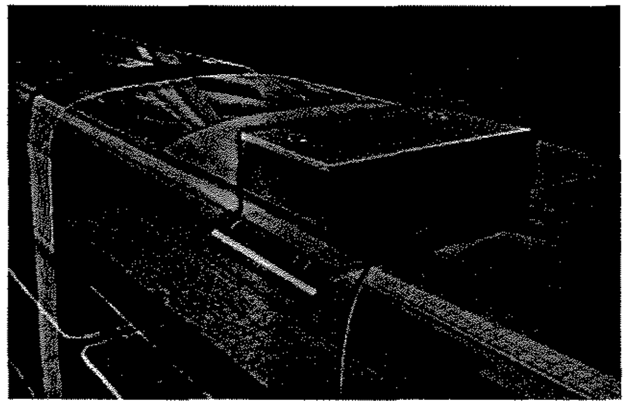
MITRAC Energy Saver

The vehicle mounted *MITRAC* Energy Saver stores the energy gained during braking and is constantly charged up during operation, either when the vehicle is in motion or waiting at a stop, picking up the power from the underground section. Doing so allows both maximum vehicle performance and constant inductive power levels, ensuring continuous operation of the vehicle just like conventional catenary systems.

Testing at Bombardier in Bautzen

The new *PRIMOVE* catenary-free solution is undergoing extensive testing at the test track of the Bombardier site in Bautzen, Germany. A low-floor tram and the test track are equipped with the *PRIMOVE* components and different phases simulating regular operation are being carried out.

ECO4 – Energy, Efficiency, Economy and Ecology
PRIMOVE catenary-free operation forms part of Bombardier's *ECO4** environmentally friendly technologies. Addressing the growing challenges among operators to reduce Energy consumption, improve Efficiency, protect the Ecology while making sense Economically, *ECO4* is the concrete validation of Bombardier's declaration – *The Climate is Right for Trains**.



MITRAC Energy Saver

Performance of the PRIMOVE System

- 250 kW continuous output of the *PRIMOVE* system, designed for a typical light rail vehicle (30 metres long, operating at a speed of 40 km/h with a gradient of six percent). A prototype vehicle is currently undergoing tests at Bombardier in Bautzen
- Performance can be provided to vary from 100 to up to 500 kW, depending on the respective vehicles and system requirements: length and number of vehicles, topographic conditions, range of application

Bombardier Transportation
Hermann Gebauer Strasse 5
1220 Vienna, Austria

Tel +43 1 25110 760
Fax +43 1 25110 335

www.bombardier.com

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